

**Computed Tomography Scan Imaging in Head Trauma Patients Based on  
Glasgow Coma Scale Score at Christian University of Indonesia General Hospital  
July 2015-June 2017**

**ABSTRACT**

Head trauma is one of the most trauma found in the emergency department. Many patients who suffer from head trauma die before arriving in the hospital. The head trauma patient evaluation is determined based on the Glasgow Coma Scale (GCS), the cause of trauma, and CT Scan results. **Aim:** The research is designed to know the image of CT Scan on Head Trauma patients by observing the early assessment of GCS. **Method:** The method of the study used was qualitative with descriptive qualitative design. **Population and Sample:** The research population is all of the patients diagnosed with head trauma from July 2015-June to 2017 in UKI General Hospital. The data is processed by using SPSS 24. **Findings:** The results from 83 patients examined found that 65 patients with a mild head injury which most CT Scan findings were normal (27,69%); 10 patients with a moderate head injury which most CT Scan findings were multiple lesions in the form of SAH and ICH (30%); and eight patients with a severe head injury which most CT Scan images are multiple lesion in the form of cranial fracture and EDH (37,5%). **Conclusion:** Head trauma mostly happens to men aged 17-25 years old, and the most often etiology is a traffic accident.

**Keywords:** *Head Trauma, GCS, CT Scan, Age, Sex, Etiology*

### **Introduction**

Head trauma is one type of trauma that is often found in the emergency department [1]. Many patients who suffer severe brain trauma die before reaching the hospital. Head trauma is damage to the head, not congenital or degenerative, but caused by an attack or physical impact from the outside, which can reduce or change consciousness and causes damage to cognitive abilities and physical function [2].

Based on data from the Centers for Disease Control and Prevention (CDC), head trauma most often occurs at 15 to over 65 years. Traffic accidents can cause the causes of head trauma, falls, bumps, attacks, and others [3]. In America, there are 1.7 million people who are affected by head trauma. In mild head trauma, many patients do not care about the symptoms they experience, so they do not come to the emergency department [4].

In evaluating head trauma patients, it can be seen based on the Glasgow Coma Scale (GCS) score, the cause of the trauma, and the CT scan results [5]. GCS can be used to assess the level of consciousness of head trauma patients by looking at three clinical aspects, namely verbal, visual, and motor responses, to determine how severe the head trauma experienced by the patient [6; 7]. The GCS score divides head trauma into 3 degrees, namely mild head injury (GCS score 13-15), moderate head injury (GCS score 9-12), and severe head injury (GCS score 8) [6; 7].

CT scan of the head is the examination of choice in patients with severe head trauma [5]. Conventional radiographs (X-Ray) of the skull are now being abandoned for head trauma cases because they cannot detect intracranial lesions [8]. Many head

trauma patients on conventional radiographs have no abnormalities, but there is bleeding in the brain when a CT scan is performed [8]. CT scanning is indicated in patients with a GCS score of less than 15 or patients with a GCS of 15 presenting with seizures, headache, vomiting, amnesia, neurological deficits, and syncope (fainting) [9]. CT Scan can detect the presence or absence of intracranial lesions early so that patients can be treated appropriately and prevent unnecessary treatment.<sup>7</sup> The optimal CT scan time is 8 hours after trauma [7].

Based on the above background, the authors are interested in researching the results of the CT Scan examination in head trauma patients based on the initial GCS assessment. Based on the background above, the problem is "How are the results of the CT Scan examination in head trauma patients based on the initial GCS assessment?" With the aim of research to determine the results of CT scan images in head trauma patients based on the initial GCS assessment at UKI Hospital for July 2015 - June 2017.

### **Literature Review**

The anatomy of the head consists of the scalp, skull bones, meninges, brain, ventricular system, and blood vessels that supply the brain [1]. A scalp is a multi-layered structure lining the skull bones [10]. Scalp consists of Skin, Connective tissue, Aponeurotic layer, Loose connective tissue, and Pericranium.

The skull bones are solid bones composed of tabula externa and tabula interna [10; 11]. The skull bones are held together by immovable joints called sutures [10; 11]. The coronal suture is located between the os. Frontale and os. Parietal, the lambdoid suture lies between the os. Parietal and os. Occipital and the sagittal suture lies between the bones. Parietal [10; 11]. The inside of the cranial base is divided into three fossae: anterior cranial fossa, middle cranial fossa, and posterior cranial fossa [10; 11]. The anterior cranial fossa houses the frontal lobes of the cerebral hemispheres. The middle cranial fossa's lateral portion houses the cerebral hemispheres' temporal lobes. The deepest portion of the posterior cranial fossa contains parts of the cerebellum, pons, and medulla oblongata [11]. Os. The sphenoid is located in the middle of the cranial base. Os. Sphenoidal stabilizes the center of the skull through the attachment of the sutures to the os. Frontale, os. Parietal, os. Occipital, and os. Ethmoidal [10; 11].

The brain is a part of the central nervous system located in the cranial cavity. The brain continues as the spinal cord after passing through the foramen magnum [10; 12]. The brain consists of the cerebrum, diencephalon, mesencephalon, and hindbrain [12]. The cerebrum and spinal cord are lined by three membranes: the dura mater, arachnoid mater, and pia mater [12].

The ventricular system contains cerebrospinal fluid that fills the gaps and aqueducts in the brain [1]. Cerebrospinal fluid (CSF) is constantly produced by the choroid plexus, which is located between the right and left lateral ventricles, flowing through the foramen of Monro into the third ventricle. In the third ventricle, it continues through the mesencephalic aqueduct to the fourth ventricle. Furthermore, out of the ventricular system, it enters the subarachnoid space, located on the entire brain and spinal cord surface. CSF will be absorbed into the venous circulation through the arachnoid granulations in the superior sagittal sinus [1].

The brain is supplied by two internal carotid arteries and two vertebral arteries. These four arteries anastomose on the inferior surface to form the circle of Willis. The internal carotid artery arises from the cavernous sinus on the medial side of the anterior

clinoid process. Then this artery turns back into the lateral cerebral sulcus. Here, it will branch into the anterior and middle cerebral arteries [12].

The vertebral artery is a branch of the first part of the subclavian artery. At the lower border of the pons, the vertebral artery joins the artery from the other side to form the basilar artery. At the upper boundary of the pons, it divides into two to form the posterior cerebral artery [12].

The circle of Willis is located in the interpeduncular fossa of the base of the skull. This circle is formed by anastomoses between the two internal carotid arteries and the two vertebral arteries, the anterior communicating artery, the anterior cerebral artery, the internal carotid artery, the posterior communicating artery, and the posterior cerebral basilar artery. The Circulus of Willis allows blood entering via the internal carotid or vertebral arteries to be distributed to any part of both the cerebral hemispheres, and the cortical and central branches of this circle supply the brain substance [10; 11; 12].

Various pathological processes affecting the brain can result in an increase in intracranial pressure (ICP), which will interfere with brain function and harm patients [1]. High ICP can have consequences that interfere with brain function and affect the patient's recovery [1]. A normal ICP at rest is approximately 10 mm Hg, an ICP higher than 20 mm Hg is considered abnormal, and an ICP higher than 40 mm Hg is regarded as a severe increase in ICP [1]. The concept of the Monro-Kellie hypothesis is that the intracranial volume is always constant [1]. If there is an increase in mass, such as a hematoma, it will cause a shift of CSF and venous blood out of the intracranial space with the same volume so that ICP remains normal [1].

According to the Brain Injury Association of America, head trauma is damage to the head, not congenital or degenerative, but caused by an attack or physical impact from the outside, which can reduce or change consciousness and cause damage to cognitive abilities and physical function [2]. According to the American Congress of Rehabilitation Medicine (ACRM), head injury is a change in mental status that occurs at the time of an accident, and the limitation of the cause is a blow to the head, head hitting an object, or acceleration-deceleration movement of the brain [13].

According to the Centers for Disease Control and Prevention (CDC), the total number of head injury cases that came to the emergency department were hospitalized and died increased from 2001-to 2010 [14]. The number of head injury cases admitted to the emergency department was relatively stable from 2001-2010, from 82.7 per 100,000 in 2001-91.7 per 100,000 in 2010 [14]. The total number of head injury cases who died from 2001-2010 decreased slightly from 18.5 per 100,000 populations in 2001 to 17.1 per 100,000 populations in 2010 [15]. In the United States, head trauma cases are more common in men than women.15 Based on CDC data, head trauma most often occurs in adults aged 15 to over 65 [14; 15]. Causes of head trauma can be due to traffic accidents, falls, bumps, attacks, and others [14; 15].

In Indonesia, research on head injuries is still minimal, so the incidence of head injuries in Indonesia is still undetermined. Based on research conducted by Nyiema Moya et al. at Hasan Sadikin Hospital, Bandung, in 2008-2010, mild head injury was 358 cases, moderate head injury in 296 patients, and severe head injury in 29 cases. Head injury is higher in males than females and is highest at 18-45 years [16].

Based on research conducted by Miranda Esther Irene Manarisip et al. at Prof. Hospital. Dr. R. D. Kandou Manado, from 89 cases of head trauma, there were ten patients with normal CT scan images, 30 patients with CT scan images of intracranial hemorrhage, 25 patients with multiple lesions, ten patients with epidural bleeding, eight

patients with skull base fractures, five patients with features of subdural hemorrhage, and one patient with features of subarachnoid hemorrhage [17].

Head injuries are classified according to the mechanism of injury, the head injury severity, and its morphology, as described in the following table.

**Table 1. Classification of Head Injury [18; 19]**

Mechanism	Blunt	High Speed (Car-motor collision) Low Speed (fall, hit)
Weight	see through Light Currently	Bullet injury Another penetrating injury GCS 13-15
Morphology	Skull Fracture	Calvary <ul style="list-style-type: none"> <li>• Linear/stellate</li> <li>• Depression/nondepression</li> <li>• Open/closed</li> </ul>
		Basic Skull <ul style="list-style-type: none"> <li>• With/without CSS leaks</li> <li>• With/without N.VII paralysis</li> </ul>
	Intracranial Lesions	Focal <ul style="list-style-type: none"> <li>• Epidural</li> <li>• Subdural</li> <li>• Intracerebral</li> </ul>
		Diffuse <ul style="list-style-type: none"> <li>• Light Composition</li> <li>• Classical Composition</li> <li>• Diffuse axon injury</li> </ul>

Head injury can cause injury to the brain and can be divided into primary and secondary damage [20]. Prior damage occurs at the time of injury due to mechanical forces causing tissue deformation. In direct head injury, there is an acceleration and de-acceleration process in the head [19]. The movement that occurs suddenly is called acceleration [19]. The sudden cessation of acceleration is called de-acceleration [19]. In head injury, a lesion may appear in the form of bleeding on the brain's surface in the form of large and small dots without damage to the dura mater. These lesions are called contusion lesions. Contusion lesions below the impact area are called coup contusion lesions, where across the impact area, there is no compression force, so there is no lesion. If a lesion is present, it is called a countercoup contusion lesion. The head does not always experience linear acceleration. Even the acceleration often experienced by the head due to trauma is rotatory. As a result of linear and rotatory acceleration, coup, contrecoup, and intermediate contusion lesions occur. The so-called intermediate contusion lesions lie between coup and countercoup contusions [19].

Secondary damage to the brain is caused by a cycle of brain swelling and ischemia, leading to a cascade of brain-damaging effects [20]. The secondary injury occurs from a few minutes to several hours after the initial injury. Whenever nerve tissue is injured, it responds in a particular pattern that causes changes in the intracellular and extracellular compartments. Some of these changes are excessive glutamine release, abnormalities in calcium flow, lactate production, and changes in the sodium pump in the cell wall that contribute to the damage—addition, and swelling of brain tissue [21]. Neurons or functional cells in the brain depend on a supply of nutrients in glucose and oxygen and are particularly susceptible to metabolic injury

when supply is interrupted [21]. Injury results in loss of the ability of the cerebral circulation to regulate the available circulating blood volume, causing ischemia in some regions of the brain [20; 21]. To determine the diagnosis, it is necessary to take a history, physical examination, and supporting investigations [22; 23].

### Research Method

This study is a descriptive survey research using a document study research design to find out the CT Scan in head trauma patients based on the initial assessment of GCS at UKI Hospital for July 2015-June, 2017. Data was collected using secondary medical record data obtained from the Surgical Clinic and Radiology polyclinic at UKI Hospital in July 2015-June 2017. This research was conducted at the General Hospital of the Christian University of Indonesia from August to December 2017. The target population for this study was patients diagnosed with head injuries at UKI General Hospital from July 2015-June to 2017. The sample comes from a population that meets the inclusion and exclusion criteria. The number of samples used in the study was 83 samples. Data was collected using secondary medical record data obtained from the Surgery and Radiology Polyclinic at UKI General Hospital. Data processing is carried out using the SPSS 24.0 program. Data is presented in graphical form.

### Result

Based on the research conducted by the author regarding head trauma at UKI General Hospital for the period July 2015-June 2017, 83 patients experienced head trauma, and the following results were obtained:

**Table 2. Characteristics of head trauma patients at UKI General Hospital for the period of July 2015-June2017**

Characteristics	N	(%)
Gender		
Male	52	62,65
Female	31	37,35
Age Group		
Toddlers 0-5 years	1	1,2
Children 5-11 years old	2	2,41
Early Teenage 12-16 years old	3	3,61
Late Teenagers 17-25 years old	20	24,10
Early Adult 26-35 years old	16	19,28
Late Adult 36-45 years old	16	19,28
Early Elderly 46-55 years old	14	16,87
Late Elderly 56-65 years old	7	8,43
Seniors > 65	4	4,82
Etiology		
Traffic accident	64	77,1
fall	16	19,3
bump	3	3,6
Diagnosis		
Mild head injury	65	78,3
Moderate head injury	10	12,0
Severe head injury	8	9,6

Based on the graph above, it can be determined that patients who experience head trauma are more common in men than women. The percentage in males is 62.65%, or 52 people from 83 patients, and in females is 37.35%, or 31 people from 83 patients studied.

Based on the research conducted by the authors, it was found that patients who experienced head trauma most often occurred in the late adolescent age group, namely 17-25 years (24.10%), followed by the early adult age group 26-35 years (19.28%), adults last age, namely 34-45 years (19.28%), early elderly 46-55 years (16.87%), late elderly 56-65 years (8.43%), seniors over 65 years (4.82%), early teens 12-16 years (3.61%), children 5-11 years (2.41%) and toddlers 0-5 years (1.20%).

The results obtained are that traffic accidents (KLL) are the most common cause of head trauma in UKI General Hospital, followed by falls and collisions. The percentage of head trauma caused due to traffic accidents is 77.11%, or as many as 64 head trauma patients the caused is traffic accidents. The rate of causes of head trauma due to falls was 19.28%, namely 16 patients who came with head trauma due to falls. The percentage of head trauma caused due to impact is 3.61% or as many as three patients from 83 patients studied came with head trauma due to influence.

Then, it can be determined that patients with mild head injuries most often occur at UKI General Hospital, followed by moderate head injuries and severe head injuries. The percentage of patients with a mild head injury was 78.31%, or as many as 65 patients with a mild head injury. In patients with a moderate head injury, as many as 12.05% or ten patients with a medium head injury. Eight patients with severe head injuries came with severe head injuries or around 9.64%.

Besides, it is determined that there were 18 patients with regular CT scans (21.69%), ten patients (12.05%), cranial fracture images (10.05%), and subdural hemorrhage (SDH) CT Scan (SDH) 7 patients (8.43%). %, the description of multiple lesions in the form of cranial fractures with intracerebral hemorrhage (ICH) in 6 patients (7.23%), the description of numerous lesions in the form of cranial fractures with epidural hemorrhage (EDH) in 5 patients (6.02%), the description of multiple lesions in the form of EDH with SDH as many as five patients (6.02%), various lesions in the form of cranial fractures accompanied by SDH in 4 patients (4.82%), multiple lesions in the form of ICH accompanied by EDH in 4 patients (4.82%). Patients with CT scan images of numerous lesions in the form of subarachnoid hemorrhage (SAH), cranial fractures accompanied by SAH in 3 patients (3.61%), multiple SDH lesions with ICH in 3 patients (3.61%), various lesions in the form of SAH accompanied by ICH in 3 patients (3.61%), pneumoencephalitis with EDH in 3 patients (3.61%) and pneumoencephalitis with ICH in 3 patients (3.61%). In patients with multiple lesions in the form of EDH accompanied by hygroma in 2 patients (2.41%), skull fracture with EDH and pneumoencephalitis in 2 patients (2.41%), and multiple lesion features in the form of cerebral infarction with SAH and perifocal edema as many as two patients (2.41%).

GCS is classified into 3, namely GCS 13-15, GCS 9-12, and GCS 8. Based on the data taken, head trauma patients with GCS 13-15 most often found normal CT scan images (27.69%), which also gave an abnormal CT scan. The most abnormal CT scan images were cranial fractures (12.31%), followed by SDH (10.77%). Multiple lesion images in the form of cranial fractures with ICH (7.69%), cranial fractures accompanied by SDH (6.15%), EDH with SDH (6.15%), multiple lesion descriptions in the form of SDH accompanied by ICH (4.62%), pneumoencephalitis with EDH (4.62%),

pneumoencephalitis with ICH (4.62 %), multiple lesion features in the form of cranial fracture with EDH (3.08%), cerebral infarction with SAH and perifocal edema (3.08%), multiple lesion features with SAH, cranial fracture with SAH (1,54%), and EDH with hygroma (1.54%).

The results of CT scan images in head trauma patients with GCS 9-12 were the most common with SAH accompanied by ICH (30%), followed by cranial fractures (20%), CT scan images of SAH (20%), multiple lesions in the form of skull fractures accompanied by SAH (20%) and the appearance of various lesions in the form of cranial fractures with ICH (10%).

In head trauma patients with a GCS of less than 8, CT scan images of multiple lesions were most often found in cranial fractures accompanied by EDH (37.50%), followed by cranial fractures accompanied by EDH and pneumoencephalitis (25%). In addition, a CT scan was also found in the form of EDH with SDH (12.50%), ICH with EDH (12.50%), and EDH with hygroma (12.50%).

Based on the research results, it was found that the incidence of head trauma was more significant in men than in women, with a percentage of 62.53%. The same results were also found in a study conducted by Miranda Esther and colleagues, where the distribution of head trauma cases was dominated by men (76%) [17]. In a survey conducted by Morgado et al., more men were exposed to head trauma (80.4%) than women [24]. Men are more at risk of head trauma because men are more physically active than women [17; 25]. Men are more often in dangerous situations such as driving a motor vehicle, fighting, construction workers, and others.

## Discussion

The age characteristic most often affected by head trauma was the late adolescent age group, namely 17-25 years (24.10%). The second and third highest age groups are early adults (26-35 years) and late adults (36-45 years), where the percentages are 19.28%, respectively. Based on a study conducted by Akanji et al., head trauma often occurs at 21-30 years (23.8%) [26]. According to research conducted by Crandall, the age group with the most frequent occurrence of head trauma is the adolescent and adult age group due to several factors, such as during adolescence, many use motorized vehicles at high vehicle speeds, are less alert, and are not careful [27]. For the adult age group, the head injury rate is high because of the group's high level of activity or mobility [28].

The most significant cause of head trauma is traffic accidents (77.11%). Similar results were found in a study conducted by Nurfaise, where traffic accidents (87.2%) were the leading cause of head trauma [29]. Based on research conducted by Farschian et al., the most common cause of head trauma is traffic accidents (72.9%) [30]. The high number of traffic accidents can occur due to a lack of public awareness of personal safety in driving and the number of violations of traffic regulations. According to the World Health Organization (WHO), traffic accidents are the leading cause of head injuries due to an increase in motorized vehicles, which increases the risk of traffic accidents [31]. Traffic accidents often occur in motorcycle users without helmets or wearing not appropriate helmets and do not meet standards [17].

Minor head injury (78.31%) was the most frequent diagnosis of head trauma in the UKI General Hospital for July 2015-June to 2017. The same results were also found in a study conducted by Nyiema Moya et al. at Hasan Sadikin Hospital, Bandung. in 2010. The incidence of mild head injury was more significant than moderate head injury and

severe head injury [16]. The percentage of mild head injuries in 2010 was 91.5%. For moderate head injury and severe head injury, it was 4.2%, respectively [16].

**The most common CT scan images found were normal CT scan images (21.69%).** The highest abnormal picture was found, namely, the picture of cranial fracture (12.05%), and the second highest was subdural hemorrhage (8.43%). The same results were also found by Surendra Maharjan et al., they found the most CT scan images in head trauma patients, namely normal photos (75.4%), but for the second order, the most CT scan images were epidural hemorrhage (7.9%) and the third order is subdural hemorrhage (3.2%) [33/42]. In a study conducted by Sedat Dalbayrak et al. in Istanbul, Turkey, the most CT scan images were found, namely, cranial fracture images (74%) or as many as 84 patients with cranial fracture images on CT Scan results from 112 patients [32].

**The most common CT scan images of the head with GCS 13-15 were normal images (27.69%),** for the most abnormal images were cranial fractures (12.31%) and subdural hemorrhages (10.31%).,77%). In a study conducted by Raja S Vignesh et al. at Madras Institute of Neurology, cranial fractures were the most common CT scan findings in patients with GCS 13-15 (39%) [33].

The damage that occurs in patients with GCS 13-15 has not interfered with the ARAS (Ascending Reticular Activating System) system, so the patient's level of consciousness is still good [34]. This ARAS system will be excited by sensory nerves and transmit impulses to the cerebral cortex so that a person is in full consciousness. If the transmission of these impulses is interrupted, it will cause a decrease in consciousness.

**The most common CT scan images found in head trauma patients with GCS 9-12** are multiple lesion images, namely subarachnoid hemorrhage and intracerebral hemorrhage (30.00%). The same results were found in a study conducted by Mohamed Labib Ahmed El Moghier. The most common head CT scan was multiple lesions (67.1%), where more than one lesion was found on CT scan [35].

Multiple subarachnoid hemorrhages and intracerebral hemorrhage lesions can occur due to the rupture of small blood vessels in the brain in the subarachnoid space or rotation, causing tearing of the subependymal veins on the surface of the ventricles of the brain. This multiple lesion appearance can also be due to blood from intracerebral hemorrhage flowing into the subarachnoid space [36]. Subarachnoid hemorrhage and intracerebral hemorrhage can cause disturbances in circulation and absorption of cerebrospinal fluid, which can cause hydrocephalus and decreased consciousness because it will suppress the ARAS system.

**The most common CT scan images found in head trauma patients with a GCS of less than eight at the UKI General Hospital for July 2015-June to 2017** were multiple lesion images in the form of cranial fractures and epidural hemorrhage (37.50%). In contrast to the study conducted by Margado et al., the CT scan results that they found in patients with severe head injuries were the presence of subgaleal hematomas, namely 15 patients out of 64 patients with severe head injuries. Most CT scans after subgaleal hematoma showed multiple lesions in 11 out of 64 patients [24].

Multiple lesions can reduce the level of consciousness due to an increase in the volume of bleeding to increase intracranial pressure and suppress the thalamus and brain stem. It will disrupt the ARAS system, which is a system to keep someone awake.

## Conclusion

Based on research conducted at UKI General Hospital for the period July 2015-June to 2017, it can be concluded that a CT Scan examination is the primary modality in diagnosing head trauma patients and needs to be done even though the patient's awareness is still good. Based on the data obtained, the most common CT scan images found in patients with GCS 13-15 were typical images (27.69%). In patients with GCS 9-12 were multiple lesions, namely SAH and ICH (30.00%), and in patients with GCS 8, the most were various lesions in the form of cranial fractures and EDH (37.50%). The most common diagnosis was minor head injury (78.31%). Respondents who experienced the most head trauma were male (62.65%), in the 17-25-year age group (24.10%), with the most etiology being traffic accidents (77.1%). Thus, there is a need for research with a more extended period with more samples to provide more representative results, and testing hypotheses need further investigation.

## References

- [1] Moran, Mary E., and Richard George. "Past Present and Future of Simulation in Trauma." (2019).
- [2] Nelasari, Diamond, Astri Sumandari, and Ridha Sasmitha Ajiningrum. "Traumatic Brain Injury." *KESANS: International Journal of Health and Science* 1, no. 4 (2022): 357-367.
- [3] Daugherty, Jill, Dana Waltzman, Juliet Haarbauer-Krupa, Karen Thomas, and Kelly Sarmiento. "State-Level Numbers and Rates of Traumatic Brain Injury-Related Emergency Department Visits, Hospitalizations, and Deaths by Sex, 2014." *Journal of Head Trauma Rehabilitation* 35, no. 6 (2020): E481-E489.
- [4] Druzgal, T. Jason, Alisa D. Gean, Yvonne W. Lui, Alexander M. Norbash, Cyrus Raji, David W. Wright, and Michael Zeineh. "Imaging Evidence and Recommendations for Traumatic Brain Injury: Conventional Neuroimaging Techniques." *Journal of the American College of Radiology* 2, no. 12 (2015): e1-e14.
- [5] Sah, S. K., N. D. Subedi, K. Poudel, and M. Mallik. "Correlation of Computed Tomography findings with Glasgow Coma Scale in patients with acute traumatic brain injury." *Journal of College of Medical Sciences-Nepal* 10, no. 2 (2014): 4-9.
- [6] Middleton, Paul M. "Practical use of the Glasgow Coma Scale; a comprehensive narrative review of GCS methodology." *Australasian Emergency Nursing Journal* 15, no. 3 (2012): 170-183.
- [7] Nayebaghayee, Hossein, and Tahmineh Afsharian. "Correlation between Glasgow Coma Scale and brain computed tomography-scan findings in head trauma patients." *Asian journal of neurosurgery* 11, no. 1 (2016): 46.
- [8] Kuttenger, Johannes. *Craniofacial trauma: diagnosis and management*. Edited by Nicolas Hardt. Berlin: Springer, 2010.
- [9] Morgado, Fabiana Lenharo, and Luiz Antônio Rossi. "Correlation between the Glasgow Coma Scale and computed tomography imaging findings in patients with traumatic brain injury." *Radiologia Brasileira* 44, no. 1 (2011): 35-41.
- [10] Drake, Richard, Richard Lee Drake, Wayne Vogl, and Adam WM Mitchell. *Gray's basic anatomy*. Elsevier Health Sciences, 2012.

- [11] Moore, Keith L., F. A. Dalley, and Anne MR Agur. "Clinically Oriented Anatomy. International edition." (2010): 564.
- [12] Snell, R. S. "Anatomi klinis berdasarkan sistem, trans." *L Sugiharto, EGC, Jakarta, Hal* (2012): 122-127.
- [13] Roozenbeek, Bob, Andrew IR Maas, and David K. Menon. "Changing patterns in the epidemiology of traumatic brain injury." *Nature Reviews Neurology* 9, no. 4 (2013): 231-236.
- [14] Moy, Ernest, Macarena C. Garcia, Brigham Bastian, Lauren M. Rossen, Deborah D. Ingram, Mark Faul, Greta M. Massetti et al. "Leading causes of death in nonmetropolitan and metropolitan areas—United States, 1999–2014." *MMWR Surveillance Summaries* 66, no. 1 (2017): 1.
- [15] Weisberg, Leon A., Richard L. Strub, and Carlos A. Garcia. *Essentials of clinical neurology*. Aspen Pub, 1989.
- [16] Zamzami, Nyiemas Moya, Iwan Fuadi, and A. Muthalib Nawawi. "Angka Kejadian dan Outcome Cedera Otak di RS. Hasan Sadikin Bandung Tahun 2008-2010." *Jurnal Neuroanestesi Indonesia* 2, no. 2 (2013): 89-94.
- [17] Manarisip, Miranda Esther Irene, Maximillian Ch Oley, and Hilman Limpeleh. "Gambaran CT Scan Kepala Pada Penderita Cedera Kepala Ringan di Blu RSUP Prof. Dr. RD Kandou Manado Periode 2012–2013." *e-CliniC* 2, no. 2 (2014).
- [18] Susanto, Albert. "Peranan CT Scan Kepala dalam Diagnosis Nyeri Kepala Kronis." *Cermin Dunia Kedokteran* 41, no. 3 (2014): 192-197.
- [19] Mardjono, M., and P. Sidharta. "Mekanisme Trauma Susunan Saraf Pusat." *Dalam: Mardjono. M., dan Sidharta, P. Neurologi Klinis Dasar. Jakarta: Dian Rakyat* (2008): 250-260.
- [20] Japardi, Iskandar. "Cedera kepala: memahami aspek-aspek penting dalam pengelolaan penderita cedera kepala." *PT Bhuana Ilmu Populer, Jakarta* (2004).
- [21] Lombardo, M. C. "Cedera Sistem Saraf Pusat." *Dalam: Price SA, Wilson LM, eds. Patofisiologi: Konsep Klinis Proses-Proses Penyakit. Edisi 6* (2006): 1167-82.
- [22] Reisner, Andrew, Joshua J. Chern, Karen Walson, Natalie Tillman, Toni Petrillo-Albarano, Eric A. Sribnick, Laura S. Blackwell, Zaev D. Suskin, Chia-Yi Kuan, and Atul Vats. "Introduction of severe traumatic brain injury care protocol is associated with reduction in mortality for pediatric patients: a case study of Children's Healthcare of Atlanta's neurotrauma program." *Journal of Neurosurgery: Pediatrics* 22, no. 2 (2018): 165-172.
- [23] Joseph, Bellal, Randall S. Friese, Moutamn Sadoun, Hassan Aziz, Narong Kulvatunyou, Viraj Pandit, Julie Wynne, Andrew Tang, Terence O'Keefe, and Peter Rhee. "The BIG (brain injury guidelines) project: defining the management of traumatic brain injury by acute care surgeons." *Journal of Trauma and Acute Care Surgery* 76, no. 4 (2014): 965-969.
- [24] Morgado, Fabiana Lenharo, and Luiz Antônio Rossi. "Correlation between the Glasgow Coma Scale and computed tomography imaging findings in patients with traumatic brain injury." *Radiologia Brasileira* 44, no. 1 (2011): 35-41.
- [25] Unnasari, Liwa. "Literatur Review Asuhan Keperawatan Pada Pasien Cedera Kepala Berat." (2021).
- [26] Akanji, Akinwunmi Olalekan, Rachael Adeyanju Akinola, Babajide Olawale Balogun, Aliu Olabanji Akano, Omolola Mojisola Atalabi, Michael AN Akinkunmi, and Gbolahan OG Awosanya. "Computerized tomography scan and

- head injury: The experience in a tertiary hospital in Nigeria: A cross sectional study." *Medical Practice and Reviews* 6, no. 1 (2015): 1-15.
- [27] Vella, Michael A., Marie L. Crandall, and Mayur B. Patel. "Acute management of traumatic brain injury." *Surgical Clinics* 97, no. 5 (2017): 1015-1030.
- [28] Van Pelt, E. Daniëlle, Arend de Kloet, Sander R. Hilberink, Susanne AM Lambregts, Els Peeters, Marije E. Roebroek, and Coriene E. Catsman-Berrevoets. "The incidence of traumatic brain injury in young people in the catchment area of the University Hospital Rotterdam, The Netherlands." *European journal of paediatric neurology* 15, no. 6 (2011): 519-526.
- [29] Nurfaise, Nurfaise. "Hubungan Derajat Cedera Kepala Dan Gambaran Ct Scan Pada Penderita Cedera Kepala Di RSUD Dr Soedarso Periode Mei-juli 2012." PhD diss., Tanjungpura University.
- [30] Farshchian, Nazanin, Firoozeh Farshchian, and Mansour Rezaei. "Correlation between Glasgow coma scale and brain CT-scan findings in traumatic patients." *Journal of Injury and Violence Research* 4, no. 3 Suppl 1 (2012).
- [31] World Health Organization. "Helm: Manual keselamatan jalan untuk pengambil keputusan dan praktisi." *Jakarta: Global Road Safety Partnership-Indonesia* (2014).
- [32] Dalbayrak, Sedat, Sevtap Gumustas, B. A. L. Ahmet, and Gur Akansel. "Early and delayed CT findings in patients with mild-to-moderate head trauma." *Turkish Neurosurgery* 21, no. 4 (2011).
- [33] Vignesh, Raja S., H. Chelladuraidandian, and Heber Anandan. "Computed Tomography Scan Findings and Glasgow Coma Scale 15 in Head Trauma Patients." *INTERNATIONAL JOURNAL OF SCIENTIFIC STUDY* 5, no. 3 (2017): 195-197.
- [34] Blyth, Brian J., and Jeffrey J. Bazarian. "Traumatic alterations in consciousness: traumatic brain injury." *Emergency Medicine Clinics* 28, no. 3 (2010): 571-594.
- [35] El Moghier, Mohamed Labib Ahmed. "Correlation between brain imaging and Glasgow Coma Scale in traumatic head injury in pediatrics." *Intern J Med Imag* 3, no. 03 (2015): 63-68.
- [36] Le, Tuong H., and Alisa D. Gean. "Imaging of head trauma." In *Seminars in Roentgenology*, vol. 41, no. 3, pp. 177-189. 2006.